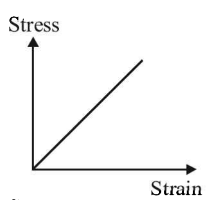
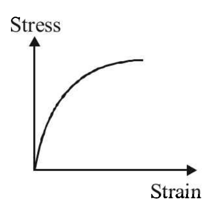
8 Mechanical Properties of Solids

Conceptual MCQs

1. According to Hook's law of elasticity, if stress is increased, then the ratio of stress to strain
   (a) becomes zero (b) remains constant
   (c) decreases (d) increases
2. The breaking stress of a wire depends upon
   (a) length of the wire (b) radius of the wire
   (c) material of the wire (d) shape of the cross-section
3. Substances which can be stretched to cause large strains are called
   (a) isomers (b) plastomers
   (c) elastomers (d) polymers
4. Which of the following graphs represents stress-strain variation for elastomers?

   (a)
   

   (b)
   

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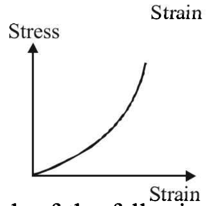
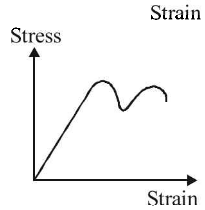
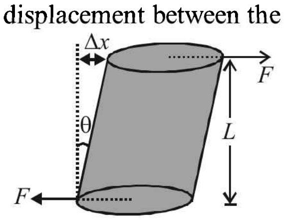
   

   (d)
   

5. Which of the following substances has highest value of Young's modulus?
   (a) Aluminium (b) Iron
   (c) Copper (d) Steel
6. Which one of the following affects the elasticity of a substance ?
   (a) Change in temperature (b) Hammering and annealing
   (c) Impurity in substance (d) All of these
7. A and B are two wires. The radius of A is twice that of B. They are stretched by the same load. Then the stress on B is
   (a) equal to that on A (b) four times that on A
   (c) two times that on A (d) half that on A
8. A wire fixed at the upper end stretches by length ℓ by applying a force F. The work done in stretching is
   (a) $2F\ell$ (b) $F\ell$ (c) $\frac{F}{2\ell}$ (d) $\frac{F\ell}{2}$
9. With rise in temperature, the Young's modulus of elasticity
   (a) increases (b) decreases
   (c) remains unchanged (d) None of these
10. Which of the following statements is correct regarding Poisson's ratio?
    (a) It is the ratio of the longitudinal strain to the lateral strain.
    (b) Its value is independent of the nature of the material.
    (c) It is unitless and dimensionless quantity.
    (d) The practical value of Poisson's ratio lies between 0 and 1.
11. If two equal and opposite deforming forces are applied parallel to the cross-sectional area of the cylinder as shown in the figure, there is a relative displacement between the opposite faces of the cylinder.
    The ratio of Δx to L is known as

    (a) longitudinal strain
    (b) volumetric strain
    (c) shearing strain
    (d) Poisson's ratio
12. For a constant hydraulic stress on an object, the fractional change in the object volume $\left(\frac{\Delta V}{V}\right)$ and its bulk modulus (B) are related as
    (a) $\frac{\Delta V}{V} \propto B$ (b) $\frac{\Delta V}{V} \propto \frac{1}{B}$
    (c) $\frac{\Delta V}{V} \propto B^2$ (d) $\frac{\Delta V}{V} \propto B^{-2}$
13. Among solids, liquids and gases, which posses the greatest bulk modulus?
    (a) Solids (b) Liquids
    (c) Gases (d) Both solids and liquids
14. The length of an iron wire is L and area of cross-section is A. The increase in length is l on applying the force F on its two ends. Then which of the following statements is correct?
    (a) Increase in length is inversely proportional to its length
    (b) Increase in length is proportional to area of cross-section
    (c) Increase in length is inversely proportional to area of cross-section
    (d) Increase in length is proportional to Young's modulus
15. A steel rod has a radius R = 9.5 mm and length L = 81 cm. A force F = 6.2×10^4 N stretches it along its length. What is the stress in the rod
    (a) 0.95×10^8 N/m^2 (b) 1.1×10^8 N/m^2
    (c) 2.2×10^8 N/m^2 (d) 3.2×10^8 N/m^2

Application Based MCQs

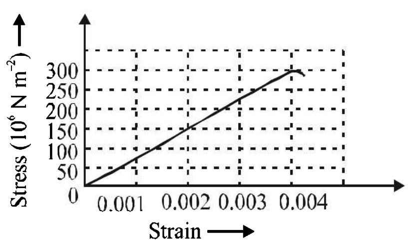
16. The radii and Young's moduli of two uniform wires *A* and *B* are in the ratio 2 : 1 and 1 : 2 respectively. Both wires are subjected to the same longitudinal force. If the increase in length of the wire *A* is one per cent, the percentage increase in length of the wire *B* is

(a) 1.0 (b) 1.5 (c) 2.0 (d) 3.0

17. Two identical solid balls, one of ivory and the other of wet clay are dropped from the same height on the floor. After striking the floor,

(a) ivory ball will rise to a greater height than wet clay ball.
(b) ivory ball will rise to a lesser height than wet clay ball.
(c) both balls will rise to the same height.
(d) data is insufficient.

18. Figure shows the strain-stress curve for a given material. The Young's modulus of the material is

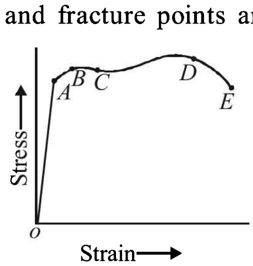


(a) 5×10^9 N m^{-2} (b) 5×10^{10} N m^{-2}
(c) 7.5×10^9 N m^{-2} (d) 7.5×10^{10} N m^{-2}

19. A wire of length *L* has a linear mass density μ and area of cross-section *A* and the Young's modulus *Y* is suspended vertically from a rigid support. The extension produced in the wire due to its own weight is

(a) $\frac{\mu g L^2}{YA}$ (b) $\frac{\mu g L^2}{2YA}$ (c) $\frac{2\mu g L^2}{YA}$ (d) $\frac{2\mu g L^2}{3YA}$

20. The stress-strain graph for a metal wire is as shown in the figure. In the graph, the region in which Hooke's law is obeyed, the ultimate strength and fracture points are represented by



(a) OA, C, D
(b) OB, D, E
(c) OA, D, E
(d) OB, C, D

21. When a certain weight is suspended to a long uniform wire its length increases by one cm. If the same weight is suspended to another wire of the same material and length but having a diameter half of the first one, the increase in its length will be

(a) 0.5 cm (b) 2 cm (c) 4 cm (d) 8 cm

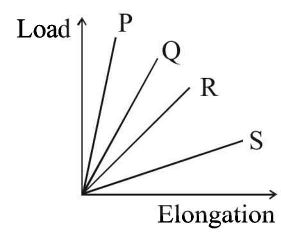
22. What per cent of length of wire increases by applying a stress of 1 kg weight/mm^2 on it?
(Y = 1×10^{11} N/m^2 and 1 kg weight = 9.8 newton)

(a) 0.0067% (b) 0.0098%
(c) 0.0088% (d) 0.0078%

23. A force of 6×10^6 Nm^{-2} is required for breaking a material. Then density ρ of the material is 3×10^3 kg m^{-3}. If the wire is to break under its own weight, the length of the wire made of that material should be (take g = 10 ms^{-2})

(a) 20m (b) 200m (c) 100m (d) 2000m

24. The load versus elongation graph for four wires is shown. The thickest wire is



(a) *P* (b) *Q* (c) *R* (d) *S*

25. Two wires of equal lengths are made of the same material. Wire A has a diameter that is twice as that of wire B. If identical weights are suspended from the ends of these wires, the increase in length is

(a) four times for wire A as for wire B
(b) twice for wire A as for wire B
(c) half for wire A as for wire B
(d) one-fourth for wire A as for wire B

26. A force of 10^3 newton, stretches the length of a hanging wire by 1 millimetre. The force required to stretch a wire of same material and length but having four times the diameter by 1 millimetre is

(a) 4×10^3 N (b) 16×10^3 N
(c) $\frac{1}{4} \times 10^3$ N (d) $\frac{1}{16} \times 10^3$ N

27. Identical springs of steel and copper ($Y_{steel} > Y_{copper}$) are equally stretched. Then

(a) Less work is done on copper spring.
(b) Less work is done on steel spring.
(c) Equal work is done on both the springs.
(d) Data is incomplete.

28. A metalic rod of length *l* and cross-sectional area A is made of a material of Young modulus Y. If the rod is elongated by an amount *y*, then the work done is proportional to

(a) y (b) $\frac{1}{y}$ (c) y^2 (d) $\frac{1}{y^2}$

29. A steel cable with a radius 2 cm supports a chairlift at a ski area. If the maximum stress is not to exceed 10^8 N m^{-2}, the maximum load the cable can support is

(a) $4\pi \times 10^5$ N (b) $4\pi \times 10^4$ N

(c) $2\pi \times 10^5$ N (d) $2\pi \times 10^4$ N

30. Two parallel and opposite forces each 5000 N are applied tangentially to the upper and lower faces of a cubical metal block of side 25 cm. The angle of shear is

(The shear modulus of the metal is 80 GPa.)

(a) 10^{-4} rad (b) 10^{-5} rad (c) 10^{-6} rad (d) 10^{-7} rad

31. A square lead slab of side 50 cm and thickness 10 cm is subjected to a shearing force (on its narrow face) of 9×10^4 N. The lower edge is riveted to the floor. How much will the upper edge be displaced?

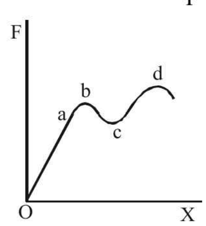
(Shear modulus of lead = 5.6×10^9 N m^{-2}

(a) 0.16mm (b) 1.6mm (c) 0.16cm (d) 1.6cm

32. Two rods *A* and *B* of the same material and length have radii r_1 and r_2 respectively. When they are rigidly fixed at one end and twisted by the same torque applied at the other end, the ratio $\left[\dfrac{\text{the angle of twist at the end of A}}{\text{the angle of twist at the end of B}}\right]$ equals to

(a) $\dfrac{r_1^2}{r_2^2}$ (b) $\dfrac{r_1^3}{r_2^3}$ (c) $\dfrac{r_2^4}{r_1^4}$ (d) $\dfrac{r_1^4}{r_2^4}$

33. The diagram shown below represents the applied forces per unit area with the corresponding change X (per unit length) produced in a thin wire of uniform cross section in the curve shown. The region in which the wire behaves like a liquid is



(a) ab

(b) bc

(c) cd

(d) Oa

34. The Young's modulus of a metal is 2×10^{12} dyne/cm^2 and its breaking stress is 11000 kg/cm^2. In case of longitudinal strain the maximum energy that can be stored per cubic metre of this metal is approximately (Assume g = 10 m/s^2)

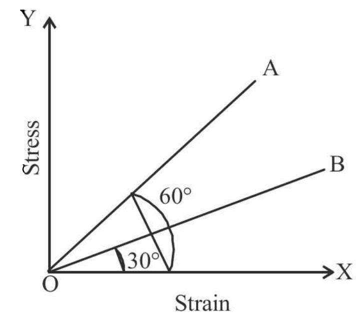
(a) 58.28×10^5 J (b) 30.25×10^5 J

(c) 37.15×10^5 J (d) 15.15×10^5 J

35. The upper end of a wire of diameter 12mm and length 1m is clamped and its other end is twisted through an angle of 30°. The angle of shear is

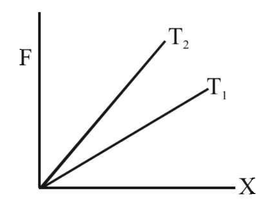
(a) 18° (b) 0.18° (c) 36° (d) 0.36°

36. The stress versus strain graphs for wires of two materials A and B are as shown in the figure. If Y_A and Y_B are the Young's moduli of the materials, then



(a) $Y_B = 2Y_A$ (b) $Y_A = Y_B$ (c) $Y_B = 3Y_A$ (d) $Y_A = 3Y_B$

37. The diagram below shows the change in the length X of a thin uniform wire caused by the application of stress F at two different temperatures T_1 and T_2. The variation shown suggests that



(a) $T_1 > T_2$

(b) $T_1 < T_2$

(c) $T_2 > T_1$

(d) $T_1 \geq T_2$

38. One end of a uniform wire of length L and of weight W is attached rigidly to a point in the roof and a weight W_1 is suspended from its lower end. If S is the area of cross-section of the wire, the stress in the wire at a height 3L/4 from its lower end is

(a) $\dfrac{W_1}{S}$ (b) $\dfrac{W_1 + (W/4)}{S}$

(c) $\dfrac{W_1 + (3W/4)}{S}$ (d) $\dfrac{W_1 + W}{S}$

39. A ball is falling in a lake of depth 200 m creates a decrease 0.1 % in its volume at the bottom. The bulk modulus of the material of the ball will be

(a) 19.6×10^{-8} N/m^2 (b) 19.6×10^{10} N/m^2

(c) 19.6×10^{-10} N/m^2 (d) 19.6×10^8 N/m^2

40. A 5 m long aluminium wire (Y = 7×10^{10} N m^{-2}) of diameter 3 mm supports a 40 kg mass. In order to have the same elongation in a copper wire (Y = 12×10^{10} Nm^{-2}) of the same length under the same weight, the diameter should now be, in mm

(a) 1.75 (b) 1.5 (c) 2.3 (d) 5.0

Skill Based MCQs

41. A wire of length L is hanging from a fixed support. The length changes to L_1 and L_2 when mass M_1 and M_2 are suspended respectively from its free end. Then L is equal to

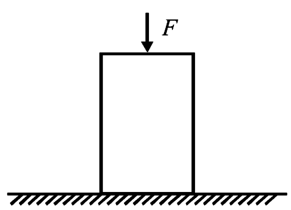
(a) $\frac{L_1+L_2}{2}$ (b) $\sqrt{L_1L_2}$

(c) $\frac{L_1M_2+L_2M_1}{M_1+M_2}$ (d) $\frac{L_1M_2-L_2M_1}{M_2-M_1}$

42. A material has poisson's ratio 0.50. If a uniform rod of it suffers a longitudinal strain of 2×10^{-3}, then the percentage change in volume is

(a) 0.6 (b) 0.4 (c) 0.2 (d) Zero

43. A metal cylinder of length L is subjected to a uniform compressive force F as shown in the figure. The material of the cylinder has Young's modulus Y and Poisson's ratio σ. The change in volume of the cylinder is



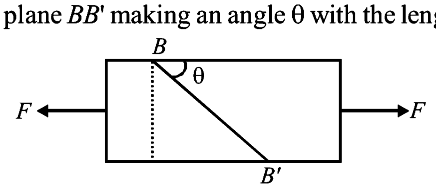
(a) $\frac{\sigma FL}{Y}$

(b) $\frac{(1-\sigma)FL}{Y}$

(c) $\frac{(1+2\sigma)FL}{Y}$

(d) $\frac{(1-2\sigma)FL}{Y}$

44. A bar of cross-sectional area A is subjected to two equal and opposite tensile forces at its ends as shown in figure. Consider a plane BB' making an angle θ with the length.



The ratio of tensile stress to the shearing stress on the plane BB' is

(a) tan θ (b) sec θ (c) cot θ (d) cos θ

45. A rod of length l and radius r is joined to a rod of length $l/2$ and radius $r/2$ of same material. The free end of small rod is fixed to a rigid base and the free end of larger rod is given a twist of θ°, the twist angle at the joint will be

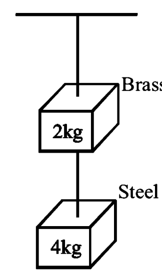
(a) θ/4 (b) θ/2 (c) 5θ/6 (d) 8θ/9

46. A rubber cord catapult has cross-sectional area 15 mm^2 and initial length of rubber cord is 8 cm. It is stretched to 5 cm and then released to project a missile of mass 5g. Taking $Y_{rubber} = 4 \times 10^8$ N/m^2, velocity of projected missile is

(a) 20 ms^{-1} (b) 100 ms^{-1}

(c) 193.6 ms^{-1} (d) 209.8 ms^{-1}

47. If the ratio of lengths, radii and Young's modulus of steel and brass wires shown in the figure are a, b, and c, respectively. The ratio between the increase in lengths of brass and steel wires would be



(a) $\frac{b^2a}{2c}$

(b) $\frac{bc}{2a^2}$

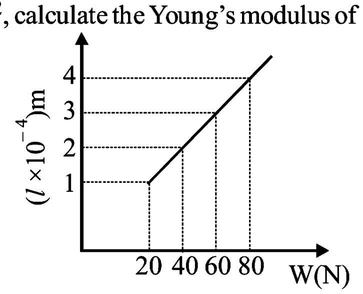
(c) $\frac{ba^2}{2c}$

(d) $\frac{a}{2b^2c}$

48. A wire elongates by ℓ mm when a load W is hanged from it. if the wire goes over a pulley and two weights W each are hung at the two ends, the elongation of the wire will be (in mm)

(a) 2ℓ (b) zero (c) ℓ/2 (d) ℓ

49. The adjacent graph shows the extension (Δl) of a wire of length 1m suspended from the top of a roof at one end with a load W connected to the other end. If the cross-sectional area of the wire is 10^{-6} m^2, calculate the Young's modulus of the material of the wire



(a) 2×10^{11} N/m^2

(b) 2×10^{-11} N/m^2

(c) 2×10^{-12} N/m^2

(d) 2×10^{-13} N/m^2

50. In steel, the young's modulus and the strain at the breaking point are 2×10^{11} N m^{-2} and 0.15 respectively. The stress at the breaking point for steel is therefore

(a) 1.33×10^{11} Nm^{-2} (b) 1.33×10^{12} Nm^{-2}

(c) 7.5×10^{-13} Nm^{-2} (d) 3×10^{-13} Nm^{-2}

ANSWER KEY

Conceptual MCQs															
1	(b)	3	(c)	5	(d)	7	(b)	9	(b)	11	(c)	13	(a)	15	(c)
2	(c)	4	(c)	6	(d)	8	(d)	10	(c)	12	(b)	14	(c)		
Application Based MCQs															
16	(c)	19	(b)	22	(b)	25	(d)	28	(c)	31	(a)	34	(b)	37	(a)
40	(c)														
17	(a)	20	(c)	23	(b)	26	(b)	29	(b)	32	(c)	35	(b)	38	(c)
18	(d)	21	(c)	24	(a)	27	(b)	30	(c)	33	(b)	36	(d)	39	(d)
Skill Based MCQs															
41	(d)	42	(b)	43	(d)	44	(a)	45	(d)	46	(c)	47	(d)	48	(d)
49	(a)	50	(d)												